Claims

1. Method for designing a technical system which is characterized by parameters, including state variables and diagnostic variables which depend on the state variables:

- in which the technical system is specified by a system of equations, with the state variables being the solutions of the system of equations;

- in which a measurement park, incorporating first measured variables, is analyzed, whereby the first measured variables are measured in the technical system with a prescribed accuracy, and depend on the state variables;

- in which second measured variables, which depend on the state variables, can be measured in the technical system with a predetermined accuracy;

- in which first sensitivity variables are determined for the first measured variables and/or second sensitivity variables for the second measured variables;

- in which, to determine the first sensitivity variables, a determination is made of the magnitude of the influence which a change in the accuracy of measurement of the first measured variables has on at least one selected parameter, and to determine the second sensitivity variables, a determination is made of the magnitude of the influence which the measurement of the second measured variables has on at least one selected parameter;

- in which the measurement park is changed, depending on the

first and/or second sensitivity variables, in such a way that the accuracy of one or more of the first measured variables is changed and/or one or more of the first measured variables is taken out of the measurement park and/or one or more of the second measured variables is added into the measurement park;

- in which the amended measurement park is used in designing the technical system.

2. Method in accordance with claim 1, whereby the accuracy of a first measured variable is increased if the first sensitivity variable for this measured variable lies within a predefined value range and/or a first measured variable is taken out of the measurement park if the first sensitivity variable for this measured variable lies within a predefined value range and/or a second measured variable is added into the measurement park if the second sensitivity variable for this measured variable lies within a predefined value range.

3. Method in accordance with claim 1 or 2, whereby the technical system is described by a system of equations $H(x)=(H_1(x),...,H_m(x))=0$, where $x=(x_1,...,x_n)$ is a vector in which the components are the state variables x_i.

4. Method in accordance with claim 3, in which the following matrices are calculated:
   - a matrix N, which spans the null space of the Jacobian matrix of H,
   - a matrix W, such that $W^T \cdot W$ is the inverse of the covariance matrix of the first measured variables $y_i=b_i(x)$, where the entries in the covariance matrix are the covariances $\sigma_{ij}^2= E((y_i - E(y_i))(y_j - E(y_j)))$, where

$E(y)$ is the expected value of y;

- a matrix M which is the pseudoinverse matrix of $A=W\cdot Db\cdot N$, where Db is the Jacobian matrix of the first measured variables $y_i=b_i(x)$.

5. Method in accordance with claim 4, in which
- at least one of the selected parameters is a selected state variable which can be determined via the first measured variables;
- one or more of the first sensitivity variables Φ_{yjx1} represents in each case the ratio of the change in accuracy $\Delta\sigma_{11}^2/x_1 = \Delta E((x_1 - E(x_1))^2)/x_1$ of the selected state variable x_1 to the change in accuracy $\Delta\sigma_{jj}^2/y_j = \Delta E((y_j - E(y_j))^2)/y_j$ of a first measured variable y_j;
- the first sensitivity variables are determined from the following formula:

$$\Phi_{y_j x_1} = \frac{\sigma^2_{jj}}{\sigma^2_{11}} \cdot r^2_{1j}$$

where r_{1j} is the element in the 1^{th} line and the j^{th} column of the matrix $N\cdot M\cdot W$.

6. Method in accordance with claim 4 or 5, in which
- at least one of the selected parameters is a selected diagnostic variable which can be determined via the first measured variables;
- a matrix Dd is determined, this being the Jacobian matrix of the diagnostic variables $d_i=d_i(x)$;
- one or more of the first sensitivity variables $\Phi_{yj\,dn}$ represents in each case the ratio of the change in accuracy $\Delta\sigma_{nn}^2/d_n = \Delta E((d_n - E(d_n))^2)/d_n$ of the selected diagnostic variable d_n to the change in accuracy $\Delta\sigma_{jj}^2/y_j = \Delta E((y_j - E(y_j))^2)/y_j$ of a first measured variable y_j;

- the first sensitivity variables are determined by the following formula:

$$\Phi_{y_j d_n} = \frac{\sigma^2_{jj}}{\sigma^2_{nn}} \cdot s^2_{nj}$$

where s_{nj} is the element in the n^{th} line and the j^{th} column of $Dd \cdot N \cdot M \cdot W$.

7. Method in accordance with one of the claims 4 to 6, in which

- at least one of the selected parameters is a selected state variable which can be determined via the first measured variables;
- one or more of the second sensitivity variables represents, in each case, the variance $\sigma_{k->x1}{}^2$ of the selected state variable x_l when a second measured variable, the value of which is a state variable x_k with the variance σ_k, is being added to the measurement park;
- the second sensitivity variables are determined by the following formula:

$$\sigma^2_{k->xl} = m_l{}^T \cdot m_l - \frac{(m_k{}^T \cdot m_l)^2}{\sigma_k{}^2 + m_k{}^T \cdot m_k},$$

where m_i is the i^{th} column of the matrix $M^T \cdot N$.

8. Method in accordance with one of the claims 4 to 7, in which

- at least one of the selected parameters is a selected diagnostic variable which can be determined via the first measured variables;
- a matrix Dd, which is the Jacobian matrix of the diagnostic variables $d_i = d_i(x)$, is determined;
- one or more of the second sensitivity variables

represents, in each case, the variance $\sigma_{k\text{->}dn}^2$ of the selected diagnostic variable d_n when a second measured variable, the value of which is a state variable x_k which has a variance σ_k, is being added to the measurement park;

- the second sensitivity variables are determined by the following formula:

$$\sigma^2_{k\text{->}dn} = q_n^T \cdot q_n - \frac{(m_k^T \cdot q_n)^2}{\sigma^2_k + m_k^T \cdot m_k}$$

where m_i is the ith column of the matrix $M^T \cdot N^T$, and q_n is the nth column of the matrix and $M^T \cdot N^T \cdot Dd^T$.

9. Method in accordance with one of the claims 4 to 8, in which

- at least one of the selected parameters is a selected state variable which cannot be determined via the first measured variables;
- a matrix P, which is the orthogonal projection onto the null space of A, is determined;
- a second measured variable is determined, the value of which is a state variable x_k, and which is to be added into the measurement park so that the selected state variable can be uniquely determined;
- one of the second sensitivity variables represents the variance $\sigma_{k\text{->}x1}^2$ of the selected state variable when the second measured variable x_k which has been determined, and which has the variance σ_k, is being added to the measurement park;
- the second sensitivity variable is determined by the following formula:

$$\|p\|^2 \quad \| \qquad \|p\| \qquad \|^2$$

$$\sigma^2_{k\to x1} = \sigma^2_k \cdot \frac{\qquad}{\|p_k\|^2} + \left\| m_1 - \frac{\qquad}{\|p_k\|} m_k \right\|,$$

with $p = Pn_1$, where n_1 is the 1^{th} column of the matrix N^T, and m_i is the i^{th} column of the matrix $M^T \cdot N^T$ and p_k is the k^{th} column of the matrix $P \cdot N^T$.

10. Method in accordance with one of the claims 4 to 9, in which

- at least one of the selected parameters is a selected diagnostic variable which cannot be determined via the first measured variables;
- a matrix Dd, which is the Jacobian matrix of the diagnostic variables $d_i = d_i(x)$, is determined;
- a matrix P, which is the orthogonal projection onto the null space of A, is determined;
- a second measured variable is determined, the value of which is a state variable x_k, and which is to be added into the measurement park so that the selected state variable can be uniquely determined;
- one of the second sensitivity variables represents the variance $\sigma_{k\to dn}^2$ of the selected diagnostic variable d_n when the second measured variable x_k which has been determined, and which has the variance σ_k, is being added into the measurement park;
- the second sensitivity variable is determined by the following formula:

$$\sigma^2_{k\to dn} = \sigma^2_k \cdot \frac{\|p\|^2}{\|p_k\|^2} + \left\| M^T \cdot c_n - \frac{\|p\|}{\|p_k\|} m_k \right\|^2,$$

with $p = Pc_n$, where c_n is the n^{th} column of the matrix

$N^T \cdot Dd^T$, m_k is the k[th] column of the matrix $M^T \cdot N^T$ and p_k is the k[th] column of the matrix $P \cdot N^T$.

11. Method in accordance with claim 9 or 10, by which the matrix $P \cdot N^T$ is searched for the column such that p is a linear function of this column, where the index k of this column specifies that the second measurement value x_k is to be added into the measurement park so that the selected parameter can be uniquely determined.

12. Method in accordance with one of the claims 7 to 11, in which the standard deviation σ_k of the second measured variable is 1% of the value of the second measured variable.

13. Device for analyzing a technical system which is equipped in such a way that a method in accordance with one of the preceding claims can be performed.

14. Computer program produce which has a storage medium on which is stored a computer program which can be executed on a computer and with which the method in accordance with one of the claims 1 to 12 can be performed.